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Hood effectiveness and entrainment of subsurface air: Impact on IAQ in a Seattle hospital

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The occupants of an unusual 3-story wing of a hospital, entirely underground, had complaints related to sick building syndrome, including the presence of sewer odors suspected of being entrained from the nearby principal city sewer main and exacerbated by the negatively-balanced pressure deliberately being maintained within the building. Problems with the efficiency of the more than 40 hoods were also suspected.

Different types of perfluorocarbon tracer (PFT) sources were deployed on each of the 3 floors, the sewer main, and the hoods. Passive sampling was performed during Tests 1 and 3, over 5-day periods each, to quantify each floors air infiltration and exfiltration rates, the rates of air exchange between the floors, and the source rates of the sewer and hood PFTs entrained into each floor relative to the total source strength deployed. The calculated sewer rates were then equated to a percentage composition of sewer air found at several locations throughout the three floors. Test 2 was performed to verify some of the earlier Test 1 measurements.

The ventilation rates determined with the PFT technology were found to be in good agreement with the rated fan capacities and total northwest (NW)-wing air change per hour (ACH) rates were identical in the two primary tests (12.9 ± 1.8 and $12.9 \pm 1.6 h^{-1}$, respectively). The exhaust air fan rating for Floor 2 was 53,000 cfm (90,000 m^3/h), comparable to measured values during Tests 1 and 3 of 118,000 ± 33,000 and 117,000 ± 25,000 m^3/h, respectively; the Floor M1 rating of 32,000 cfm (54,000 m^3/h) agreed perfectly with the measured values (55,000 ± 8,000 and 48,500 ± 7,000 m^3/h, respectively).

Air exchange between the three floors was nearly absent. The major exchange was about 15% of Floor 1 air flowing to Floor 2, and about 5% to Floor M1, implying that Floor 2 was the most negatively-balanced zone, Floor M1 next, and Floor 1 with the least negative pressure. All else being equal, Floor 2, then, should have had the most problems with soil air and sewer air entrainment and hood performance.

An examination of the chromatograms from the analysis of passive samplers placed in several locations on the floors, in the exhaust fan ducts (appropriately shielded), in sewer manholes and building sewer vents, and in several outside air and air intake locations showed the presence not only of the PFTs, but also, in the case of sewer air samples, a unique consistent signature of four prominent peaks.

The percentage of sewer air found on each floor, estimated from both the PFT and the "tracers of opportunity", confirmed the conclusion above, namely, areas of Floor 2 had 1 to 2% of the air as sewer air, but Floors 1 and M1, only 0.00 to 0.05% as sewer air. The outside air intake plenum only contained 0.01 to 0.03% sewer air, so the high concentration of sewer air on Floor 2 is consistent with the hypothesized and known negatively-balanced pressures, causing flow reversals and soil air influx.

The amount of hood air tracer found on each floor as a percentage of the amount released into hoods on that floor followed the same trend, namely, areas of Floor 2 had 2 to 3% of its hood tracer showing up in the occupied space; Floor 1, 1.5%; and Floor M1, 0.5%. Again it appeared that the negative pressure on Floor 2, and in room NW-220 in particular, was causing performance problems. Even the outside air intake plenum showed significant hood tracer (0.4%) probably from internal re-entrainment.

Possible pathways for migration of sewer air pollutants into Room NW-220 were through the soil surrounding the building or through malfunctioning drain traps in the room. Correction of drain trap problems, relocation of three building sewer vents and the laboratory waste line serving Room NW-220, and reduction of the excessive negative pressure in NW-220 through rebalancing, appears to have prevented airflow of unacceptable indoor air contaminants into that area.

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